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The Role of Blockchain Technologies in Transforming Supply Chains Towards Social and Environmental Sustainability

Keywords: blockchain technology, supply chains, social-environmental sustainability, digital transformation

Introduction & Background: In today's economy, supply chain networks are the epitome of globalisation, connecting distant parts of the world in the extraction of raw materials, product design and development, manufacturing, and delivery – in short, the entire production process. Striving for ever-greater efficiency, reducing costs and wastes, exploiting opportunities for economies of scale, and aiming to fulfil the demands of global consumption patterns, production and supply cycles are composed of a vast network of inexpensive, specialised suppliers (Gardner et al., 2019). Supply chains are defined as "three or more entities (organisations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer" (Mentzer et al., 2011, p.4). In their current format, however, supply chains exhibit greater complexity, which is accompanied by various challenges and shortcomings, such as limited traceability and transparency of intermediate production steps obscuring the origins of goods and circumstances of production.

The European Union's (EU) draft directive on corporate sustainability due diligence is the newest regulatory text that, if accepted, requires large, limited liability companies active in the EU, and those operating in high-risk sectors, to report on human rights and environmental impacts as well as corresponding mitigation measures. To respond to public and regulatory demand for products adhering to social and environmental minimum standards, corporate responsibility and sustainability claims, businesses exhibit interest in blockchain technology – a digital, distributed, permanent record of immutable, transparent, and tamper-proof data. By means of cryptographic engineering, input data is saved in individual blocks, which are encrypted, time-stamped, permanent, and intrinsically linked to all previous blocks on the chain (Härting et al., 2020). Any newly added block requires the approval of all members of the blockchain via a consensus mechanism, therefore getting rid of a central authority. Blockchains can be public or private, depending on who can access the information and participate in the creation of new blocks.

There are numerous studies outlining the shortcomings and challenges global complex supply chains face, and the need to address these to be able to meet consumer demands and regulatory requirements (cf. Free & Hecimovic, 2021; Gurzawska, 2020; Hastig & Sodhi, 2020; Kandil et al., 2020). There is also great overlap between the functioning of supply chains and the implications on sustainability (Birkel & Müller, 2021; Ciccullo et al., 2018), a concept that has received immense attention by the public, politics, businesses and in academia. However, few studies have approached the intersection of blockchain technology, supply chains and sustainability (Paliwal et al., 2020; Saberi et al., 2019). This is why the paper at hand is guided by the following research question: *What is the contribution of blockchain technology to transform global supply chains towards environmental and social sustainability?*

Conceptual Framework: *Sustainability* is understood along the lines of the triple bottom line framework, that recognises the interconnected, inseparable nature of economic, environmental, and social sustainability (Birkel & Müller, 2021). Moreover, following the strong sustainability approach of ecological economics, sustainability entails efforts in each of the three realms and considers the corresponding capital stocks as noninterchangeable. Thus, technological advancements shall not offset environmental destruction, depletion, or extinction.

Data & Methods: A thematic analysis of academic and grey literature builds the basis for understanding the underpinnings of supply chains, blockchain technology and sustainability, and how these may converge. In order to build a foundational understanding of the topics of supply chains and blockchain technologies, and to present the current state of the art, collecting and converging information from secondary sources is considered appropriate (Ritchie & Lewis, 2003). The findings are henceforth closely attached to existing research and other publications and are largely presented descriptively. A thematic analysis is a data-driven research practice available to use for all kinds of data sources, in this case written documents. At its centre lies the structured clustering of findings into codes, categories, and broader themes (Ritchie & Lewis, 2003). This method facilitates the handling of large amounts of data by means of thematic structuring of arguments and passages of the cited literature.

Results: The presentation of results first lays out characteristics of supply chains and the prevailing challenges, both internal and external. This is followed by an introduction in the blockchain architecture, inherent opportunities and shortcomings, as well as barriers and incentives to adopt blockchain in supply chains.

Discussion: These findings are discussed according to economic, social, and environmental sustainability, and placed into the wider context of digitalisation of the economy, to which blockchain technologies can form one contributing aspect. In recognition of different company foci and sizes, technology adoption may be more or less feasible and expedient. Yet, the study finds that inherent qualities of blockchain technologies can contribute to increase transparency along supply chains, shedding light on risks, harmful behaviours, and negative environmental and social externalities. This is considered a necessary first step to address these risks with corresponding mitigation measures.

Conclusions: The thesis concludes that blockchain-based solutions can contribute to sustainability by means of transparency, strengthened product lifecycle assessments, increased efficiency and automation. However, these efficiency gains must be weighed against the energy and resource consumption of technology implementation, as well as feasibility concerns.

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